PRODUCTION OF PHASE SHIFT MASK

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Abstract

PURPOSE: To prevent the etching of a substrate in the production of a halftone phase shift mask and to prevent deviation in resolution characteristics.
CONSTITUTION: A first translucent film 2a comprising Cr of 50&angst film thickness and a second translucent film 2b comprising MoSiON of 1500&angst film thickness are formed on a transparent substrate 1 (a). A photosensitive resin 4 is applied and drawn with electron beams (b). After development, the second translucent film 2b is etched by anisotropic etching (c). The first translucent film 2a is etched by wet method (d). Then the photosensitive resin 4 is peeled (e).

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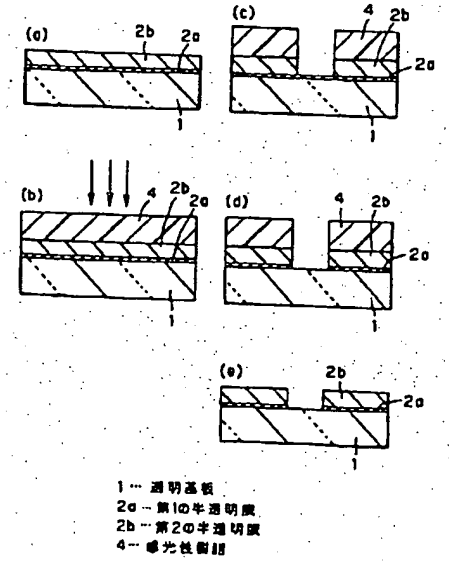
(54)【発明の名称】　位相シフトマスクの製造方法

(57)【要約】

【目的】　ハーフトーン型位相シフトマスクの製法において、基板のエッチングを防止して解像特性のずれを防止する。

【構成】　透明基板１上に、膜厚５０ÅのＣｒからなる第１の半透明膜２ａと、膜厚１５００ÅのＭｏＳｉＯＮからなる第２の半透明膜２ｂを成膜する〔図１（ａ）〕。感光性樹脂４を塗布し、電子描画する〔図１（ｂ）〕。現像後、異方性エッチングにより第２の半透明膜２ｂをエッチングする〔図１（ｃ）〕。ウエット法により第１の半透明膜２ａをエッチングする〔図１（ｄ）〕。感光性樹脂４を剥離する〔図１（ｅ）〕。



1… 透明基板
2a…第1の半透明膜
2b…第2の半透明膜
4…感光性樹脂

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【特許請求の範囲】

【請求項1】　（1）透明基板上に、透明乃至半透明の第1の位相シフト層を形成する工程と、

（2）前記第1の位相シフト層上に、この位相シフト層とはエッチング性を異にし、かつ、この位相シフト層より十分に膜厚の厚い半透明の第2の位相シフト層を形成する工程と、

（3）前記第2の位相シフト層上に、透明領域を形成すべき領域上に開口を有するエッチングマスクを形成する工程と、

（4）異方性があり、かつ、前記第1の位相シフト層に対して選択性のあるエッチング法にて第2の位相シフト層を選択的にエッチングする工程と、

（5）前記第（4）の工程の結果露出した前記第1の位相シフト層を等方性エッチング法にてエッチングする工程と、を備えることを特徴とする位相シフトマスクの製造方法。

【請求項2】　Cr、CrO、CrON、CrN、SnO_2、ITOの中のいずれかを被着して前記第1の位相シフト層を形成することを特徴とする請求項1記載の位相シフトマスクの製造方法。

【請求項3】　前記第（2）の工程における第2の位相シフト層の形成方法が、高融点金属シリサイドを酸素ガスおよび／または窒素ガスを供給しつつスパッタするものであることを特徴とする請求項1記載の位相シフトマスクの製造方法。

【発明の詳細な説明】

【0001】

【産業上の利用分野】本発明は半導体装置製造に用いる位相シフトマスクの製造方法に関し、特にハーフトーン型の位相シフトマスクの製造方法に関する。

【0002】

【従来の技術】現在、半導体素子の製造工程においては、半導体基板上にパターンを形成するために、光リソグラフィ技術を用いている。光リソグラフィでは、縮小投影露光装置によりフォトマスク（透明領域と不透明領域からなるパターンを有する透明基板であり、縮小率が1でない場合は特にレチクルとも呼ばれるがここではいずれもマスクと呼ぶことにする）のパターンを、半導体基板上に塗布された感光性樹脂に転写し、現像により感光性樹脂を所定のパターンに加工する。

【0003】従来の光リソグラフィ技術においては、露光装置のNA（Numerical Aperture；開口数）を高めることにより半導体素子パターンの微細化に対応してきた。しかし、露光装置の高NA化により解像力は向上するものの、逆に焦点深度は減少し、焦点深度の点で更なる微細化が困難となってきた。そこで、位相シフトマスク技術が開発され、実用化されてきている。位相シフトマスクは、一般にマスクを透過する光の位相を制御し、結像面での光強度分布を改善する技術である。

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【0004】位相シフトマスク技術としては各種方式のものが提案されているが、なかでもコンタクトホールパターンのような孤立パターンに対して有効な、例えば特開平4－162039に示されている、ハーフトーン方式の位相シフトマスクが注目されている。

【0005】通常のマスクは、石英等の透明基板上にクロム（Cr）からなる遮光膜パターンを設けたものであり、一方、ハーフトーン方式と呼ばれる位相シフトマスクは、透明基板上に酸化クロム等の所定の膜厚の半透明膜パターンを設けたものである。すなわち、通常マスクでは、透明基板上に、透明領域と不透明領域とが設けられ、ハーフトーン方式位相シフトマスクでは、透明領域と半透明領域とが設けられる。

【0006】そして、位相シフトマスクでは透明領域と半透明領域を透過する光の位相を互いに180度異なるようにしている。そのため、結像面上では透明領域と半透明領域の光が打ち消し合い、プロファイルの急峻な光強度分布が得られ、従来マスクよりも焦点深度や解像度を向上させることができる。

【0007】次に、このハーフトーン方式の位相シフトマスクおよびその製造方法について図面を参照して説明する。ハーフトーン方式の位相シフトマスクは、位相シフト部が透明な位相シフト層と半透明層との2層膜によって構成される2層膜方式と、位相シフト層が半透明膜によって構成される単層膜方式とに大別される。前者にはまた成膜型と基板掘り下げ型とがある。図4（a）、（b）に示されたものが2層膜方式のものであり、図4（c）に示されたものが単層膜方式のものである。

【0008】図4（a）に示すものでは、石英等の透明基板1上に、200Å程度の極薄いCr等の半透明膜2〔Crは遮光材料であるがここでは通常マスク（透過率1％程度）と同程度の透過率の膜を遮光膜とし、通常マスク以上の透過率の膜を半透明膜とする〕と、SiO_2等の透明膜3を有している。

【0009】この構造の位相シフトマスクにおいては、半透明領域の透過率は半透明膜2の膜厚で制御し、位相シフト量は透明膜3の膜厚で制御する（半透明膜2の膜厚およびその屈折率により半透膜2だけでも20～30度程度の位相差が生じるのでこの分を考慮して、全体で180度になるように透明膜3の膜厚を制御する）。よって、この構造の露光特性上の利点は、

①半透明領域の透過率を広範囲にかつ精度よく制御できる、

②位相シフト量を精度よく制御できる、点である。

【0010】次に、この構造のマスクの製造方法について説明する。まず、石英等の透明基板1上に、200～300Å程度の極薄いCrの半透明膜2を成膜し、さらにこの上にSOG（spin on glass 法によるSiO_2膜）等の透明膜を成膜したマスクブランクを作製する。次に、このマスクブランクに感光成樹脂を塗布し、マス

クパターンを描画し、現像により所定のパターンのマスクを形成する。そして、CHF_3 あるいはCF_4 ガスを用いたドライエッチングにより透明膜（SiO_2）のエッチングを行う。

【0011】このとき、その下の半透明膜（Cr）がエッチングストッパーとなるため、透明基板1にダメージを与えることなく容易にエッチングできる。そして、半透明膜をウエットエッチングにより除去した後、感光性樹脂を剥離すれば図4（a）に示される位相シフトマスクが作製される。

【0012】図4（b）には、基板掘り下げ型の位相シフトマスクの例が示されており、この型のものでは、同図に示されるように、透明基板1表面に半透明膜2を設け、透明基板を掘って位相シフト量を制御する。この構造のマスクにおいては、マスク寸法精度が高いという利点がある。すなわち、きわめて薄い半透明膜のパターン寸法を制御すれば、基板のエッチング時にはこの半透明膜がマスクとなるため、基板のエッチング部分の寸法のばらつきを少なくすることができる。

【0013】この構造の位相シフトマスクの製造方法は、まず透明基板1上に極めて薄い（200～300Å）Crの半透明膜2を成膜したマスクブランクを作製する。そして、感光性樹脂を塗布し、マスクパターンの描画を行い、現像後、半透明膜2のエッチングを行う。エッチングは、Cl_2 ガスを用いたドライエッチングあるいはウェットエッチングにより行うが、半透明膜2はきわめて薄いので、ウェットエッチングでも十分な精度で加工できる。そして、透明基板1をCHF_3 あるいはCF_4 ガスを用いたドライエッチングで位相差が180度生じるように3000Å程度の深さにエッチングする。

【0014】図4（a）、（b）に示した2層膜型のハーフトーン方式位相シフトマスクでは、位相シフト量が屈折率の低い（SiO_2 で1．5以下）透明膜の厚さによって制御されるため、位相シフト部の膜厚が厚くなり〔i線（λ＝365nm）を用いる場合で3000Å以上〕、露光特性、特に解像特性が悪化するという欠点がある。なお、ハーフトーン方式以外の位相シフトマスクは、すべて位相シフト部が透明膜によって構成されるため同様の不具合を持っている。

【0015】一方、単層膜型ハーフトーン方式のマスクは、図4（c）に示すように、CrON（酸窒化クロム）あるいはMoSiON（酸窒化モリブデンシリサイド）等の1種類の材料の半透明膜2のみで、透過率と位相差を同時に制御する構造となっている。この構造のマスクにおいては、この半透明膜の屈折率が通常2以上と大きいためその厚さを1500Å程度と、通常マスクの遮光膜（1000Å）の膜厚の1．5倍程度に抑えることができ、マスクの立体的構造（半透明膜2開口部の断面形状）が解像特性に与える影響を低く抑えることができる。

【0016】この構造のマスクの製造方法は、まず透明基板1上にCrあるいはMoSiのスパッタを行い、このときO_2（酸素）およびN_2（窒素）ガスを加えることにより、ある一定の組成のCrONあるいはMoSiONを所定の膜厚に成膜して半透明膜2を形成し、マスクブランクを作製する。そして、通常マスクの場合と同様に、1回のリソグラフィおよびエッチング工程により、マスクパターンを作製する。

【0017】ここで、Cr系の膜であればCl_2（塩素）ガス、MoSi系の材料であればC（炭素）およびF（フッ素）を含むCF_4 またはCHF_3 ガスあるいはSF_6ガスによりエッチングが可能である。このように、この型の位相シフトマスクは通常マスクと同程度の工程により作製できるという、マスク製造面での利点もある。

【0018】

【発明が解決しようとする課題】上述した、図4（a）、（b）に示した構造のマスクにおいては、マスクが厚膜の構造となるため、その構造に起因する問題が生じていた。すなわち、これらのマスクでは透明膜3あるいは透明基板1を3000Å以上エッチングしていたが、一般にこのような厚い膜を垂直に開孔することは困難で通常段差部分の側壁にテーパーが形成される。ところが、よく知られているように、この構造のマスクにおいては、透明膜や透明基板のエッチング形状がテーパーを持つほど、転写されるパターン寸法は小さくなる。

【0019】一方、図4（c）に示される従来の単層膜型ハーフトーン位相シフトマスクにおいては、MoSiONのように、Fを含んだガスのドライエッチングによりエッチング可能な材料を用いた場合、感光性樹脂との選択比は十分とれるためマスク寸法の精度は良好となるものの、透明基板1の材料である石英（SiO_2）も同じくエッチングされるため、マスク製造上の誤差が大きくなり、本来のハーフトーンマスクの性能が得られていなかった。

【0020】すなわち、透明基板1が削られると、その分位相差が当初の設定値である180度からずれることになる（石英の屈折率は約n＝1．46なので100Åエッチングされると位相差のずれは4．6度となる）。そして、一般によく知られているように、位相シフトマスクにおいては、位相差のずれはフォーカス特性（フォーカス位置と転写される寸法の関係）に大きな悪影響を及ぼすので、位相差の誤差許容範囲は±5度以内とされており、したがって透明基板1のエッチングは数10Å以下に抑えることが必要である。

【0021】なお、例えば特開平4－359254号公報には、透過型の位相シフトマスクにおいて位相シフト層となる透明膜の下層にエッチングストッパーとなる透明膜を設けることが示されているが、このような製造方

法を、このハーフトーン方式に適用して、透明基板とMoSiONの半透明膜の間に、エッチングストッパーを設けても基板エッチング防止の目的は達成されない。

【0022】それは、エッチングストッパーとなる透明膜は金属酸化物等により形成される膜であるため、ハーフトーンマスクの半透明膜とのエッチング選択比はとれず、そのためエッチングストッパーは数10Åエッチングされることになり、結局図4（c）の従来例の場合と同様に透過率および位相差に誤差が生じることになるからである。

【0023】本発明は、このような状況に鑑みてなされたものであって、その目的とするところは、位相シフト層を薄膜に形成することのできる単層膜型のハーフトーン方式位相シフトマスクにおいて、基板のエッチングを防止できるようにして高精度でかつ再現性の高いマスクを提供し得るようにすることである。

【0024】

【課題を解決するための手段】上記目的を達成するため、本発明によれば、（1）透明基板上に、透明乃至半透明の第1の位相シフト層を形成する工程と、（2）前記第1の位相シフト層上に、この位相シフト層とはエッチング性を異にし、かつ、この位相シフト層より十分に膜厚の厚い半透明の第2の位相シフト層を形成する工程と〔図1（a）、図2（a）、図3（a）〕、（3）前記第2の位相シフト層上に、透明領域を形成すべき領域上に開口を有するエッチングマスクを形成する工程と、（4）異方性があり、かつ、前記第1の位相シフト層に対して選択性のあるエッチング法にて第2の位相シフト層を選択的にエッチングする工程と〔（c）図〕、（5）前記第（4）の工程の結果露出した前記第1の位相シフト層を等方性のエッチング法にてエッチングする工程と〔（d）図〕、を備える位相シフトマスクの製造方法、が提供される。

【0025】

【実施例】次に、本発明の実施例について図面を参照して説明する。

〔第1の実施例〕図1（a）～（e）は、本発明の第1の実施例の製造方法を工程順に示した断面図である。まず、図1（a）に示すように、石英の透明基板1上にスパッタ法によりCrを50Å厚に成膜して第1の半透明膜2aを形成し、続いて同じくスパッタ法によりMoSiONを1500Å厚に成膜して第2の半透明膜2bを形成してマスクブランケットを製作する。MoSiONは、酸素（O_2）ガスおよび窒素（N_2）ガスを流しながらMoSiをスパッタして成膜した。

【0026】第2の半透明膜2bの材料としては、

① 通常の光マスクの遮光膜（Cr）と同程度の膜厚で80～97%の遮光性があり、かつ、180度近くの位相シフトを与えることができる（すなわち、屈折率：n＞2）、

② ドライエッチングが容易である、の条件を満たしていることが必要である。この条件を満たすものとしては、MoSi、WSi、TiSiの酸化物、窒化物、酸窒化物等があり、これらは、酸素ガスおよび／または窒素ガスを供給しつつ、各シリサイドをスパッタすることにより形成することができる。。

【0027】図1（a）に示されるマスクブランクにおいて、第1の半透明膜2aおよび第2の半透明膜2bからなる半透明膜により透過率が所定値なされるとともに位相シフト量は180度になされている。すなわち、透明基板1の透過率を100%としたとき、第2の半透明膜2b／第1の半透明膜2a／透明基板1の透過率Tは3～20%の範囲に設定され、かつ第1の半透明膜2aおよび第2の半透明膜2bを透過する光と透過しない光に180度の位相差を生じさせている。

【0028】次に、図1（b）に示すように、感光性樹脂4を塗布し、電子線描画装置によりマスクパターンの描画を行う。次に、図1（c）に示すように、感光性樹脂4の現像後、下記条件のドライエッチングにより、第2の半透明膜2bをエッチングする。このとき、第1の半透明膜2aはエッチングストッパーとなる。

ガス：SF_6

エッチングパワー：300W

圧力：200mTorr

ガス流量：30sccm

【0029】次に、図1（d）に示すように、硝酸第2セリウムアンモン水溶液と過塩素酸の混合液を用いたウエットエッチングにより第1の半透明膜2aを除去する。そして、最後に感光性樹脂4を剥離すれば、図1（e）に示すように、本実施例の位相シフトマスクの製造が完了する。

【0030】本実施例においては、第1の半透明膜2aのエッチングの際に、等方性エッチングのためその膜厚と同程度のサイドエッチングが生じるが、第1の半透明膜2aは十分薄くマスク寸法は第2の半透明膜2bで実質的に規定されるため、寸法精度の問題は生じない。

【0031】〔第2の実施例〕次に、図2を参照して本発明の第2の実施例について説明する。図2（a）～（e）は、本発明の第2の実施例の製造方法を工程順に示した断面図である。まず、図2（a）に示すように、石英の透明基板1上に、膜厚300ÅのCrOからなる第1の半透明膜2aと、膜厚1000ÅのMoSiONからなる第2の半透明膜2bを順次成膜する。

【0032】次に、図2（b）に示すように、感光性樹脂4を塗布し、マスクパターンの描画を行う。続いて、図2（c）に示すように、感光性樹脂4を現像した後、SF_6 を用いて第2の半透明膜2bをドライエッチングする。そして、図3（d）に示すように、第1の半透明膜をウエットエッチングにより除去し、最後に図2（e）に示すように、感光性樹脂4を剥離する。この場

合にも、第１の半透明膜２ａは第２の半透明膜に比べ薄いので、マスク寸法は第２の半透明膜２ｂで決定され、第１の半透明膜２ａのサイドエッチングはほとんど問題にならない。しかし、第１の半透明膜２ａを途中まで異方性のドライ法によりエッチングし最後の部分のみをウエット法により除去するようにしてサイドエッチングの影響を最小限に留めるようにすることもできる。

【００３３】本実施例においては、第１の半透明膜２ａの透過性が比較的高いので、第１の半透明膜と第２の半透明膜の厚さを変えることにより（第１の半透明膜を厚くしたら、合計の位相差が１８０度になるように第２の半透明膜を薄くする必要がある）、位相シフトマスクの透過率をある程度の範囲（第１および２の半透明膜それぞれ単独場合の値）で容易に変更できるという利点がある。ただし、第１の半透明膜２ａの厚さが厚くなりすぎると、この膜がマスク寸法に影響するようになるので、第１の半透明膜２ａの膜厚は第２の半透明膜２ｂより薄くする必要がある。

【００３４】［第３の実施例］次に、図３を参照して本発明の第３の実施例について説明する。図３（ａ）～（ｅ）は、本発明の第３の実施例の製造方法を工程順に示した断面図である。まず、図３（ａ）に示すように、石英の透明基板１上に、２００Å厚のSnO_2からなる透明膜３と、１３００Å厚のＭｏＳｉＯＮからなる半透明膜２とをそれぞれスパッタ法により成膜する。

【００３５】図３（ａ）に示されるマスクブランクにおいて、透明膜３および半透明膜２からなる半透明膜により透過率が所定値なされるとともに位相シフト量は１８０度になされている。すなわち、透明基板１の透過率を１００％としたとき、透明膜３／半透明膜２／透明基板１の透過率Ｔは３～２０％の範囲に設定され、かつ透明膜３および半透明膜２を透過する光と透過しない光に１８０度の位相差を生じさせている。

【００３６】次に、図３（ｂ）に示すように、感光性樹脂４を塗布し、電子線描画装置によりマスクパターンの描画を行う。次いで、図３（ｃ）に示すように、感光性樹脂４の現像後、SF_6ガスを用いたドライエッチングにより、半透明膜２をエッチングする。このとき、透明膜３がエッチングストッパーとなる。続いて、図３（ｄ）に示すように、ウエットエッチングにより透明膜３を除去する。そして、最後に、図３（ｅ）に示すように感光性樹脂４を剥離して、位相シフトマスクを製造する。

【００３７】なお、本実施例では透明膜３をエッチングストッパーとしているが、同じく透明膜をエッチングストッパーとして用いる特開平４－３５９２５４号公報に示された従来例のものとは基本的に異なっている。すなわち、この従来例ではエッチングストッパー層は基本的には基板の一部と見做される層であってそれにより生じる位相差および透過率差は問題とならない膜であるのに対し、本実施例の透明膜は制御された位相差および透過率差を生じさせる膜として利用している。

【００３８】そして、従来例ではこのエッチングストッパーがエッチングされた場合には基板がエッチングされたのと同様の効果が生じて位相差のずれの原因となるが、本発明の場合にはその後にエッチングストッパー自体を除去するため、この膜が半透明膜のドライエッチング工程時に多少のエッチングを受けることがあっても、解像特性が悪影響を受けたりマスク間の特性のばらつきが大きくなったりすることはない。なお、第１の位相シフト層を形成するための材料としては、実施例で説明したものの外、ＣｒＯＮ、ＣｒＮ等の半透明膜、、ＩＴＯ等の透明膜を用いることができる。

【００３９】

【発明の効果】以上説明したように、本発明は、半透明膜をエッチング性の異なる２層の位相シフト層によって構成し、上層の膜を異方性エッチングによりそして下層の膜を等方性エッチングにより加工して、単層型（すなわち、半透明膜により位相シフトを行わせる型）ハーフトーン方式の位相シフトマスクを形成するものであるので、透明基板がエッチングされることがなくなり、膜厚の薄い位相シフト層を有するマスクを高い精度でかつ再現性よく製造することができるようになり、良好な露光特性の位相シフトマスクを安定して製造することが可能となる。

【図面の簡単な説明】

【図１】本発明の第１の実施例の製造方法を説明するための工程順断面図。

【図２】本発明の第２の実施例の製造方法を説明するための工程順断面図。

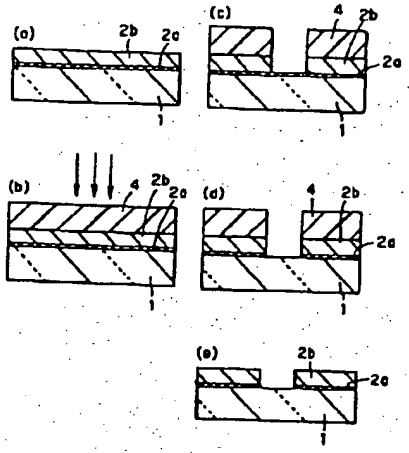
【図３】本発明の第３の実施例の製造方法を説明するための工程順断面図。

【図４】従来のハーフトーン方式位相シフトマスクの断面図。

【符号の説明】

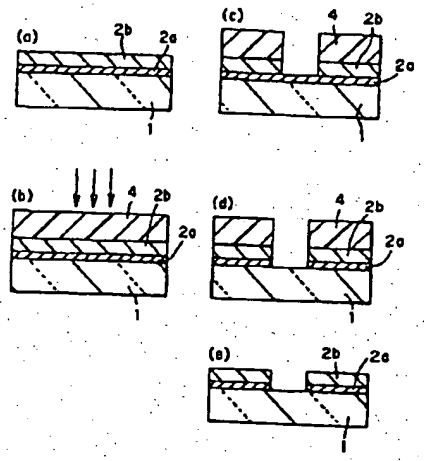
１　透明基板
２　半透明膜
２ａ　第１の半透明膜
２ｂ　第２の半透明膜
３　透明膜
４　感光性樹脂

【図1】

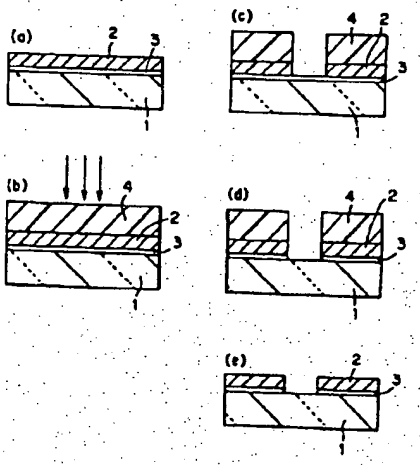


1 … 透明基板
2a … 第1の半透明膜
2b … 第2の半透明膜
4 … 感光性樹脂膜

【図2】

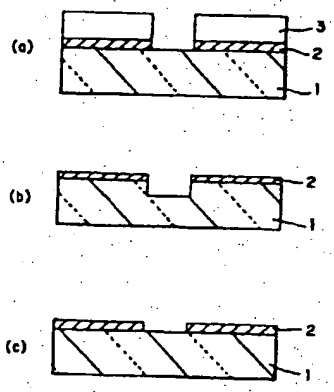


【図3】



2 … 半透明膜
3 … 遮光膜

【図4】



* NOTICES *

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CLAIMS

[Claim(s)]

[Claim 1] The manufacture method of the phase shift mask characterized by providing the following. (1) The process which forms the 1st transparent or translucent phase shift layer on a transparent substrate. (2) The process which differs in etching nature with this phase shift layer, and forms the 2nd translucent phase shift layer with fully thick thickness from this phase shift layer on the phase shift layer of the above 1st. (3) The process which forms the etching mask which has opening on the field which should form a transparent field on the phase shift layer of the above 2nd. (4) The process which **********s the phase shift layer of the above 1st which exposed the 2nd phase shift layer as a result of the process which **********s alternatively, and the process of (5) ****** (4) by the etching method which has an anisotropy and has selectivity to the phase shift layer of the above 1st by the isotropic etching method.

[Claim 2] Cr, CrO, CrON, CrN and SnO2, the manufacture method of the phase shift mask according to claim 1 characterized by putting either of the ITO(s) and forming the phase shift layer of the above 1st.

[Claim 3] The manufacture method of the phase shift mask according to claim 1 characterized by being that to which the formation method of the 2nd phase shift layer in the process of ****** (2) carries out the spatter of the refractory-metal silicide, supplying oxygen gas and/or nitrogen gas.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] this invention relates to the manufacture method of a halftone type phase shift mask especially about the manufacture method of the phase shift mask used for semiconductor device manufacture.
[0002]
[Description of the Prior Art] Now, in the manufacturing process of a semiconductor device, in order to form a pattern on a semiconductor substrate, optical lithography technology is used. In optical lithography, it imprints to the photopolymer to which the pattern of a photo mask (each will be called mask here although it is the transparent substrate which has the pattern which consists of a transparent field and an opaque field, and it is also called a reticle especially when reduction percentage is not 1) was applied by the reduction projection aligner on the semiconductor substrate, and a photopolymer is processed into a predetermined pattern by development.
[0003] In the conventional optical lithography technology, it has corresponded to detailed-ization of a semiconductor device pattern by raising NA (Numerical Aperture; numerical aperture) of an aligner. However, although resolution improves by high NA-ization of an aligner, conversely, the depth of focus decreases and the further detailed-ization serves as difficulty in respect of the depth of focus. Then, phase shift mask technology has been developed and put in practical use. A phase shift mask is the technology of controlling the phase of the light which generally penetrates a mask and improving the optical intensity distribution in an image formation side.
[0004] the thing of various methods is proposed as phase shift mask technology -- especially, to an isolated pattern like a contact hole pattern, it is effective, for example, the phase shift mask of the halftone method shown in JP,4-162039,A attracts attention
[0005] The usual mask prepares the shading film pattern which consists of chromium (Cr) on transparent substrates, such as a quartz, and, on the other hand, the phase shift mask called halftone method prepares the semi-transparent membrane pattern of predetermined thickness, such as a chrome oxide, on a transparent substrate. That is, with a mask, a transparent field and an opaque field are usually prepared on a transparent substrate, and a transparent field and a translucent field are prepared with a halftone method phase shift mask.
[0006] And the phase of the light which penetrates a transparent field and a translucent field is made to differ 180 degrees mutually with a phase shift mask. Therefore, on an image formation side, the light of a transparent field and a translucent field negates each other, the steep optical intensity distribution of a profile are obtained, and the depth of focus and resolution can be conventionally raised rather than a mask.
[0007] Next, the phase shift mask and its manufacture method of this halftone method are explained with reference to a drawing. The phase shift mask of a halftone method is divided roughly into the two-layer film method which the phase shift section consists of with the two-layer film of a transparent phase shift layer and a transparent translucent layer, and the monolayer method with which a phase shift layer

is constituted by the semi-transparent membrane. There are formed type of membranes and a substrate investigation type in the former again. It is a thing of a two-layer film method which was shown in drawing 4 (a) and (b), and it is a thing of a monolayer method which was shown in drawing 4 (c).

[0008] what is shown in drawing 4 (a) -- the transparent substrates 1 top, such as a quartz, -- SiO [semi-transparents membrane / 2 / [although Cr is shading material, it usually uses the film of permeability of the same grade as a mask (about 1% of permeability) as a shading film here, and it usually makes the film of the permeability more than a mask a semi-transparent membrane] /, such as very thin Cr, / about 200A]2 etc. -- it has the transparent membrane 3

[0009] In the phase shift mask of this structure, the permeability of a translucent field is controlled by thickness of a semi-transparent membrane 2, and the amount of phase shifts is controlled by thickness of a transparent membrane 3 (since about [semipermeable membrane 220-30 degree] phase contrast arises with the thickness of a semi-transparent membrane 2, and its refractive index, in consideration of at this rate, the thickness of a transparent membrane 3 is controlled to become 180 degrees on the whole). Therefore, the advantage on the exposure property of this structure is a point which can control the permeability of ** translucent field with a broadly and sufficient precision and which can control the amount of ** phase shifts with a sufficient precision.

[0010] Next, the manufacture method of the mask of this structure is explained. First, the mask blank which formed the about 200-300A very thin semi-transparent membrane 2 of Cr, and formed transparent membranes, such as SOG (SiO2 film by the spin on glass method), on this further on the transparent substrates 1, such as a quartz, is produced. Next, sensitization Naruki fat is applied to this mask blank, a mask pattern is drawn, and the mask of a predetermined pattern is formed by development. And CHF3 Or CF4 A transparent membrane (SiO2) is etched by the dry etching using gas.

[0011] Since the semi-transparent membrane under it (Cr) serves as an etching stopper at this time, it can etch easily, without giving a damage to the transparent substrate 1. And if a photopolymer is exfoliated after wet etching removes a semi-transparent membrane, the phase shift mask shown in drawing 4 (a) will be produced.

[0012] In drawing 4 (b), the example of a substrate investigation type phase shift mask is shown, to be shown in this drawing, a semi-transparent membrane 2 is formed in transparent substrate 1 front face, a transparent substrate is dug, and the amount of phase shifts is controlled by this type of thing. In the mask of this structure, there is an advantage that a mask dimensional accuracy is high. That is, if the pattern size of a very thin semi-transparent membrane is controlled, since this semi-transparent membrane will serve as a mask at the time of etching of a substrate, dispersion in the size of the etching portion of a substrate can be lessened.

[0013] The manufacture method of the phase shift mask of this structure produces the mask blank which formed the very thin (200-300A) semi-transparent membrane 2 of Cr on the transparent substrate 1 first. And a photopolymer is applied, a mask pattern is drawn and etching of a semi-transparent membrane 2 is performed after development. Etching is Cl2. Although the dry etching or wet etching using gas performs, since a semi-transparent membrane 2 is very thin, it is processible in precision sufficient also by wet etching. And it is CHF3 about the transparent substrate 1, Or CF4 It **********s in a depth of about 3000A so that phase contrast may arise 180 degrees in the dry etching using gas.

[0014] With the halftone method phase shift mask of a two-layer membrane type shown in drawing 4 (a) and (b), since the amount of phase shifts is controlled by thickness of the low (it is 1.5 or less at SiO2) transparent membrane of a refractive index, there is a fault that more than 3000A], an exposure property, especially a resolving property get worse by the case where the thickness of the phase shift section becomes thick and uses [i line (lambda= 365nm). In addition, since the phase shift section is constituted by the transparent membrane, all phase shift masks other than a halftone method have the same fault.

[0015] On the other hand, as shown in drawing 4 (c), the mask of a monolayer type halftone method is only the semi-transparent membrane 2 of one kind of material, such as CrON (acid nitriding chromium) or MoSiON (acid nitriding molybdenum silicide), and has permeability and structure which controls phase contrast simultaneously. In the mask of this structure, usually, 2 or more and since it is large, the refractive index of this semi-transparent membrane can usually hold down the thickness to about 1.5

times of the thickness of the shading film (1000A) of a mask with about 1500A, and can suppress low the influence to which the three-dimensional structure (cross-section configuration of semi-transparent membrane 2 opening) of a mask gives a resolving property.
[0016] By performing the spatter of Cr or MoSi and adding O2 and (oxygen) N2 gas (nitrogen) on the transparent substrate 1, first, at this time, the manufacture method of the mask of this structure forms CrON or MoSiON of a certain fixed composition to predetermined thickness, forms a semi-transparent membrane 2, and produces a mask blank. And a mask pattern is usually produced according to 1 time of lithography, and an etching process like the case of a mask.
[0017] CF4 which contains C (carbon) and F (fluorine) if it is the film of Cr system and is the material of Cl2 gas (chlorine) and a MoSi system here Or CHF3 It can etch by gas or SF6 gas. Thus, this type of phase shift mask also has an advantage in respect of [that it is usually producible with a process of the same grade as a mask] mask manufacture.
[0018]
[Problem(s) to be Solved by the Invention] In the mask of the structure which was mentioned above and which was shown in drawing 4 (a) and (b), since a mask served as structure of a thick film, the problem resulting from the structure had arisen. That is, although 3000A or more was **********ing the transparent membrane 3 or the transparent substrate 1 with these masks, it is difficult to puncture such a thick film perpendicularly generally, and a taper is usually formed in the side attachment wall of a level difference portion. However, the pattern size imprinted becomes small, so that the etching configuration of a transparent membrane or a transparent substrate has a taper in the mask of this structure as known well.
[0019] In the conventional monolayer type halftone phase shift mask shown in drawing 4 (c) on the other hand When the material which can be etched by the dry etching of the gas containing F like MoSiON is used, Since the quartz (SiO2) which is the material of the transparent substrate 1 although it becomes good [the precision of a mask size] since the selection ratio with a photopolymer can be taken enough similarly **********ed, the error on mask manufacture became large and the performance of an original halftone mask was not obtained.
[0020] That is, when the transparent substrate 1 is deleted, the part phase contrast will shift from 180 degrees which is the original set point (since the refractive index of a quartz is abbreviation n= 1.46, if 100A **********s, a gap of phase contrast will become 4.6 degrees). And since a gap of phase contrast has a big bad influence on a focal property (relation between a focal position and the size imprinted) in a phase shift mask, error tolerance of phase contrast is made into less than **5 times, therefore etching of the transparent substrate 1 needs to hold down to several 10A or less, as generally known well.
[0021] In addition, although preparing the transparent membrane which serves as an etching stopper in the lower layer of the transparent membrane which serves as a phase shift layer in a penetrated type phase shift mask is shown, for example in JP,4-359254,A, such a manufacture method is applied to this halftone method, and even if it forms an etching stopper between a transparent substrate and the semi-transparent membrane of MoSiON, the purpose of substrate etching prevention is not attained.
[0022] It is because the etch selectivity with the semi-transparent membrane of a halftone mask cannot be taken, therefore several 10A will ********** and an error will produce an etching stopper in permeability and phase contrast like the case of the conventional example of drawing 4 (c) after all, since the transparent membrane from which it serves as an etching stopper is a film formed of a metallic oxide etc.
[0023] The place which this invention is made in view of such a situation, and is made into the purpose is enabling it to offer a highly precise mask with high repeatability, as etching of a substrate can be prevented in the monolayer type halftone method phase shift mask which can form a phase shift layer in a thin film.
[0024]
[Means for Solving the Problem] The process which forms the 1st transparent or translucent phase shift layer on (1) transparent substrate according to this invention in order to attain the above-mentioned purpose, (2) With this phase shift layer, it differs in etching nature on the phase shift layer of the above

1st. And the process and [drawing 1 (a) which form the 2nd translucent phase shift layer with fully thick thickness from this phase shift layer, The process which forms the etching mask which has opening on the field which should form a transparent field on the phase shift layer of] and the drawing 2 (a) drawing 3 (a)(3) above 2nd, (4) -- the process which **********s the 2nd phase shift layer alternatively by the etching method which has an anisotropy and has selectivity to the phase shift layer of the above 1st, and [(c) view --] -- (-- five --) -- ****** -- (-- four --) -- a process -- a result -- having exposed -- the above -- the -- one -- a phase shift -- a layer -- being isotropic -- etching -- a method -- **********ing -- a process -- [-- (-- d --) -- a view --] -- having -- a phase shift -- a mask -- manufacture -- a method -- ** -- providing -- having .

[0025]

[Example] Next, the example of this invention is explained with reference to a drawing.

[1st example] drawing 1 (a) - (e) is the cross section having shown the manufacture method of the 1st example of this invention in order of the process. First, as shown in drawing 1 (a), on the transparent substrate 1 of a quartz, Cr is formed to 50A ** by the spatter, 1st semi-transparent membrane 2a is formed, similarly MoSiON is continuously formed to 1500A ** by the spatter, 2nd semi-transparent membrane 2b is formed, and a mask blanket is manufactured. Passing oxygen (O2) gas and nitrogen (N2) gas, the spatter of the MoSi was carried out and MoSiON formed membranes.

[0026] It is required to fulfill the conditions of ** with easy ** dry etching that there is 80 - 97% of shading nature as a material of 2nd semi-transparent membrane 2b by thickness of the same grade as the shading film (Cr) of a ** usual optical mask, and the phase shift of about 180 degrees can be given (namely, refractive-index:n>2). As what fulfills this condition, there are an oxide of MoSi, WSi, and TiSi, a nitride, an acid nitride, etc., and these can be formed by carrying out the spatter of each silicide, supplying oxygen gas and/or nitrogen gas.

[0027] in the mask blank shown in drawing 1 (a), permeability should predetermined-value-do by the semi-transparent membrane which consists of the 1st semi-transparent membrane 2a and the 2nd semi-transparent membrane 2b -- the amount of phase shifts is made by 180 degrees with ** That is, when the permeability of the transparent substrate 1 is made into 100%, the light which the permeability T of the 2nd semi-transparent membrane 2b / the 1st semi-transparent membrane 2a / transparent substrate 1 is set as 3 - 20% of range, and penetrates 1st semi-transparent membrane 2a and 2nd semi-transparent membrane 2b, and the light which is not penetrated are made to produce the phase contrast of 180 degrees.

[0028] Next, as shown in drawing 1 (b), a photopolymer 4 is applied and a mask pattern is drawn with electron-beam-lithography equipment. Next, as shown in drawing 1 (c), 2nd semi-transparent membrane 2b is **********ed by the dry etching of the following conditions after the development of a photopolymer 4. At this time, 1st semi-transparent membrane 2a becomes an etching stopper.

gas: -- SF6 etching power: -- 300W pressure: -- 200mTorr quantity-of-gas-flow: -- 30sccm [0029] Next, as shown in drawing 1 (d), the wet etching using the 2nd cerium Amon solution of a nitric acid and the mixed liquor of perchloric acid removes 1st semi-transparent membrane 2a. And if a photopolymer 4 is finally exfoliated, as shown in drawing 1 (e), manufacture of the phase shift mask of this example will be completed.

[0030] In this example, although side etching of the same grade as the thickness arises for isotropic etching in the case of etching of 1st semi-transparent membrane 2a, since 1st semi-transparent membrane 2a is specified substantially [it is sufficiently thin and / a mask size] at 2nd semi-transparent membrane 2b, the problem of a dimensional accuracy is not produced.

[0031] The 2nd example of this invention is explained with reference to the [2nd example], next drawing 2 . Drawing 2 (a) - (e) is the cross section having shown the manufacture method of the 2nd example of this invention in order of the process. First, as shown in drawing 2 (a), 2nd semi-transparent membrane 2b set to 1st semi-transparent membrane 2a which consists of CrO of 300A of thickness on the transparent substrate 1 of a quartz from MoSiON of 1000A of thickness is formed one by one.

[0032] Next, as shown in drawing 2 (b), a photopolymer 4 is applied and a mask pattern is drawn. Then, SF6 as shown in drawing 2 (c), after developing a photopolymer 4 It uses and dry etching of the 2nd

semi-transparent membrane 2b is carried out. And as shown in drawing 3 (d), wet etching removes the 1st semi-transparent membrane, and as shown in drawing 2 (e), finally a photopolymer 4 is exfoliated. Also in this case, since 1st semi-transparent membrane 2a is thin compared with the 2nd semi-transparent membrane, a mask size is determined by 2nd semi-transparent membrane 2b, and side etching of 1st semi-transparent membrane 2a hardly becomes a problem. However, as 1st semi-transparent membrane 2a is **********ed by the dry method of an anisotropy to the middle and only the last portion is removed by the wet method, the influence of side etching can be stopped to the minimum.

[0033] In this example, since the permeability of 1st semi-transparent membrane 2a is comparatively high, there is an advantage that the permeability of (that it is necessary to make the 2nd semi-transparent membrane thin so that total phase contrast may become 180 degrees if the 1st semi-transparent membrane is thickened), and a phase shift mask can be easily changed in a certain amount of range (each semi-transparent membrane of the 1st and 2 value in an independent case), by changing the thickness of the 1st semi-transparent membrane and the 2nd semi-transparent membrane. However, if the thickness of 1st semi-transparent membrane 2a becomes thick too much, since this film will come to influence a mask size, it is necessary to make thickness of 1st semi-transparent membrane 2a thinner than 2nd semi-transparent membrane 2b.

[0034] The 3rd example of this invention is explained with reference to the [3rd example], next drawing 3 . Drawing 3 (a) - (e) is the cross section having shown the manufacture method of the 3rd example of this invention in order of the process. first, it is shown in drawing 3 (a) -- as -- the transparent substrate 1 top of a quartz -- SnO2 of 200A ** from -- the becoming transparent membrane 3 and the semi-transparent membrane 2 which consists of MoSiON-of 1300A ** are formed by the spatter, respectively

[0035] in the mask blank shown in drawing 3 (a), permeability should predetermined-value-do by the semi-transparent membrane which consists of a transparent membrane 3 and a semi-transparent membrane 2 -- the amount of phase shifts is made by 180 degrees with ** That is, when the permeability of the transparent substrate 1 is made into 100%, the light which the permeability T of the 2/transparent substrate 1 of 3/semi-transparents membrane of transparent membranes is set as 3 - 20% of range, and penetrates a transparent membrane 3 and a semi-transparent membrane 2, and the light which is not penetrated are made to produce the phase contrast of 180 degrees.

[0036] Next, as shown in drawing 3 (b), a photopolymer 4 is applied and a mask pattern is drawn with electron-beam-lithography equipment. Subsequently, as shown in drawing 3 (c), they are after the development of a photopolymer 4, and SF6. A semi-transparent membrane 2 is **********ed by the dry etching using gas. At this time, a transparent membrane 3 serves as an etching stopper. Then, as shown in drawing 3 (d), wet etching removes a transparent membrane 3. And finally, as shown in drawing 3 (e), a photopolymer 4 is exfoliated, and a phase shift mask is manufactured .

[0037] In addition, although the transparent membrane 3 is used as the etching stopper in this example, it differs from the thing of the conventional example similarly shown in JP,4-359254,A using a transparent membrane as an etching stopper fundamentally. That is, in this conventional example, the transparent membrane of this example is used as a film which produces the phase contrast and the permeability difference which were controlled to an etching stopper layer being a layer it is considered fundamentally that is a part of substrate, and the phase contrast and the permeability difference which this produces being a film which does not pose a problem.

[0038] and although the effect that a substrate is the same with having **********ed arises and it becomes the cause of a gap of phase contrast in the conventional example when this etching stopper **********s, since the etching stopper itself is removed after that in the case of this invention, even if this film may receive some etching at the time of the dry etching process of a semi-transparent membrane, a resolving property receives a bad influence or dispersion in the property between masks becomes large -- there are nothings In addition, as a material for forming the 1st phase shift layer, although the example explained, transparent membranes, such as semi-transparents membrane, such as CrON and CrN, and ITO, can be used outside.

[0039]

[Effect of the Invention] And a lower layer film is processed by isotropic etching. the two-layer phase shift layer from which, as for this invention, etching nature differs a semi-transparent membrane as explained above -- constituting -- the upper film -- anisotropic etching -- Since the phase shift mask of a monolayer type (namely, mold in which phase shift is made to perform by semi-transparent membrane) halftone method is formed It becomes possible it to be lost for that a transparent substrate **********s, to be a high precision, and to be able to manufacture now the mask which has the thin phase shift layer of thickness with sufficient repeatability, to be stabilized and to manufacture the phase shift mask of a good exposure property.

[Translation done.]

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TECHNICAL FIELD

[Industrial Application] this invention relates to the manufacture method of a halftone type phase shift mask especially about the manufacture method of the phase shift mask used for semiconductor device manufacture.

[Translation done.]

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PRIOR ART

[Description of the Prior Art] Now, in the manufacturing process of a semiconductor device, in order to form a pattern on a semiconductor substrate, optical lithography technology is used. In optical lithography, it imprints to the photopolymer to which the pattern of a photo mask (each will be called mask here although it is the transparent substrate which has the pattern which consists of a transparent field and an opaque field, and it is also called a reticle especially when reduction percentage is not 1) was applied by the reduction projection aligner on the semiconductor substrate, and a photopolymer is processed into a predetermined pattern by development.
[0003] In the conventional optical lithography technology, it has corresponded to detailed-ization of a semiconductor device pattern by raising NA (Numerical Aperture; numerical aperture) of an aligner. However, although resolution improves by high NA-ization of an aligner, conversely, the depth of focus decreases and the further detailed-ization serves as difficulty in respect of the depth of focus. Then, phase shift mask technology has been developed and put in practical use. A phase shift mask is the technology of controlling the phase of the light which generally penetrates a mask and improving the optical intensity distribution in an image formation side.
[0004] the thing of various methods is proposed as phase shift mask technology -- especially, to an isolated pattern like a contact hole pattern, it is effective, for example, the phase shift mask of the halftone method shown in JP,4-162039,A attracts attention
[0005] The usual mask prepares the shading film pattern which consists of chromium (Cr) on transparent substrates, such as a quartz, and, on the other hand, the phase shift mask called halftone method prepares the semi-transparent membrane pattern of predetermined thickness, such as a chrome oxide, on a transparent substrate. That is, with a mask, a transparent field and an opaque field are usually prepared on a transparent substrate, and a transparent field and a translucent field are prepared with a halftone method phase shift mask.
[0006] And the phase of the light which penetrates a transparent field and a translucent field is made to differ 180 degrees mutually with a phase shift mask. Therefore, on an image formation side, the light of a transparent field and a translucent field negates each other, the steep optical intensity distribution of a profile are obtained, and the depth of focus and resolution can be conventionally raised rather than a mask.
[0007] Next, the phase shift mask and its manufacture method of this halftone method are explained with reference to a drawing. The phase shift mask of a halftone method is divided roughly into the two-layer film method which the phase shift section consists of with the two-layer film of a transparent phase shift layer and a transparent translucent layer, and the monolayer method with which a phase shift layer is constituted by the semi-transparent membrane. There are formed type of membranes and a substrate investigation type in the former again. It is a thing of a two-layer film method which was shown in drawing 4 (a) and (b), and it is a thing of a monolayer method which was shown in drawing 4 (c).
[0008] what is shown in drawing 4 (a) -- the transparent substrates 1 top, such as a quartz, -- SiO [semi-transparents membrane / 2 / [although Cr is shading material, it usually uses the film of permeability of the same grade as a mask (about 1% of permeability) as a shading film here, and it usually makes the

film of the permeability more than a mask a semi-transparent membrane] /, such as very thin Cr, / about 200A]2 etc. -- it has the transparent membrane 3

[0009] In the phase shift mask of this structure, the permeability of a translucent field is controlled by thickness of a semi-transparent membrane 2, and the amount of phase shifts is controlled by thickness of a transparent membrane 3 (since about [semipermeable membrane 220-30 degree] phase contrast arises with the thickness of a semi-transparent membrane 2, and its refractive index, in consideration of at this rate, the thickness of a transparent membrane 3 is controlled to become 180 degrees on the whole). Therefore, the advantage on the exposure property of this structure is a point which can control the permeability of ** translucent field with a broadly and sufficient precision and which can control the amount of ** phase shifts with a sufficient precision.

[0010] Next, the manufacture method of the mask of this structure is explained. First, the mask blank which formed the about 200-300A very thin semi-transparent membrane 2 of Cr, and formed transparent membranes, such as SOG (SiO2 film by the spin on glass method), on this further on the transparent substrates 1, such as a quartz, is produced. Next, sensitization Naruki fat is applied to this mask blank, a mask pattern is drawn, and the mask of a predetermined pattern is formed by development. And CHF3 Or CF4 A transparent membrane (SiO2) is etched by the dry etching using gas.

[0011] Since the semi-transparent membrane under it (Cr) serves as an etching stopper at this time, it can etch easily, without giving a damage to the transparent substrate 1. And if a photopolymer is exfoliated after wet etching removes a semi-transparent membrane, the phase shift mask shown in drawing 4 (a) will be produced.

[0012] In drawing 4 (b), the example of a substrate investigation type phase shift mask is shown, to be shown in this drawing, a semi-transparent membrane 2 is formed in transparent substrate 1 front face, a transparent substrate is dug, and the amount of phase shifts is controlled by this type of thing. In the mask of this structure, there is an advantage that a mask dimensional accuracy is high. That is, if the pattern size of a very thin semi-transparent membrane is controlled, since this semi-transparent membrane will serve as a mask at the time of etching of a substrate, dispersion in the size of the etching portion of a substrate can be lessened.

[0013] The manufacture method of the phase shift mask of this structure produces the mask blank which formed the very thin (200-300A) semi-transparent membrane 2 of Cr on the transparent substrate 1 first. And a photopolymer is applied, a mask pattern is drawn and etching of a semi-transparent membrane 2 is performed after development. Etching is Cl2. Although the dry etching or wet etching using gas performs, since a semi-transparent membrane 2 is very thin, it is processible in precision sufficient also by wet etching. And it is CHF3 about the transparent substrate 1. Or CF4 It **********s in a depth of about 3000A so that phase contrast may arise 180 degrees in the dry etching using gas.

[0014] With the halftone method phase shift mask of a two-layer membrane type shown in drawing 4 (a) and (b), since the amount of phase shifts is controlled by thickness of a transparent membrane with a low (it is 1.5 or less at SiO2) refractive index, there is a fault that more than 3000A], an exposure property, especially a resolving property get worse by the case where the thickness of the phase shift section becomes thick and uses [i line (lambda= 365nm). In addition, since the phase shift section is constituted by the transparent membrane, all phase shift masks other than a halftone method have the same fault.

[0015] On the other hand, as shown in drawing 4 (c), the mask of a monolayer type halftone method is only the semi-transparent membrane 2 of one kind of material, such as CrON (acid nitriding chromium) or MoSiON (acid nitriding molybdenum silicide), and has permeability and structure which controls phase contrast simultaneously. In the mask of this structure, usually, 2 or more and since it is large, the refractive index of this semi-transparent membrane can usually hold down the thickness to about 1.5 times of the thickness of the shading film (1000A) of a mask with about 1500A, and can suppress low the influence to which the three-dimensional structure (cross-section configuration of semi-transparent membrane 2 opening) of a mask gives a resolving property.

[0016] By performing the spatter of Cr or MoSi and adding O2 and (oxygen) N2 gas (nitrogen) on the transparent substrate 1, first, at this time, the manufacture method of the mask of this structure forms

CrON or MoSiON of a certain fixed composition to predetermined thickness, forms a semi-transparent membrane 2, and produces a mask blank. And a mask pattern is usually produced according to 1 time of lithography, and an etching process like the case of a mask.

[0017] CF4 which contains C (carbon) and F (fluorine) if it is the film of Cr system and is the material of Cl2 gas (chlorine) and a MoSi system here Or CHF3 It can etch by gas or SF6 gas. Thus, this type of phase shift mask also has an advantage in respect of [that it is usually producible with a process of the same grade as a mask] mask manufacture.

[Translation done.]

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EFFECT OF THE INVENTION

[Effect of the Invention] the two-layer phase shift layer from which etching nature differs a semi-transparent membrane in this invention as explained above -- constituting -- the upper film -- anisotropic etching -- and a lower layer film is processed by isotropic etching, and the phase shift mask of a monolayer type (namely, mold in which phase shift is made to perform by semi-transparent membrane) halftone method is formed Therefore, it becomes possible it to be lost for that a transparent substrate **********s, to be a high precision, and to be able to manufacture now the mask which has the thin phase shift layer of thickness with sufficient repeatability, to be stabilized and to manufacture the phase shift mask of a good exposure property.

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TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] In the mask of the structure which was mentioned above and which was shown in drawing 4 (a) and (b), since a mask served as structure of a thick film, the problem resulting from the structure had arisen. That is, although 3000A or more was **********ing the transparent membrane 3 or the transparent substrate 1 with these masks, it is difficult to puncture such a thick film perpendicularly generally, and a taper is usually formed in the side attachment wall of a level difference portion. However, the pattern size imprinted becomes small, so that the etching configuration of a transparent membrane or a transparent substrate has a taper in the mask of this structure as known well.

[0019] In the conventional monolayer type halftone phase shift mask shown in drawing 4 (c) on the other hand When the material which can be etched by the dry etching of the gas containing F like MoSiON is used, Since the quartz (SiO2) which is the material of the transparent substrate 1 although it becomes good [the precision of a mask size] since the selection ratio with a photopolymer can be taken enough similarly **********ed, the error on mask manufacture became large and the performance of an original halftone mask was not obtained.

[0020] That is, when the transparent substrate 1 is deleted, the part phase contrast will shift from 180 degrees which is the original set point (since the refractive index of a quartz is abbreviation n= 1.46, if 100A **********s, a gap of phase contrast will become 4.6 degrees). And since a gap of phase contrast has a big bad influence on a focal property (relation between a focal position and the size imprinted) in a phase shift mask, error tolerance of phase contrast is made into less than **5 times, therefore etching of the transparent substrate 1 needs to hold down to several 10A or less, as generally known well.

[0021] In addition, although preparing the transparent membrane which serves as an etching stopper in the lower layer of the transparent membrane which serves as a phase shift layer in a penetrated type phase shift mask is shown, for example in JP,4-359254,A, such a manufacture method is applied to this halftone method, and even if it forms an etching stopper between a transparent substrate and the semi-transparent membrane of MoSiON, the purpose of substrate etching prevention is not attained.

[0022] It is because the etch selectivity with the semi-transparent membrane of a halftone mask cannot be taken, therefore several 10A will ********** and an error will produce an etching stopper in permeability and phase contrast like the case of the conventional example of drawing 4 (c) after all, since the transparent membrane from which it serves as an etching stopper is a film formed of a metallic oxide etc.

[0023] The place which this invention is made in view of such a situation, and is made into the purpose is enabling it to offer a highly precise mask with high repeatability, as etching of a substrate can be prevented in the monolayer type halftone method phase shift mask which can form a phase shift layer in a thin film.

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MEANS

[Means for Solving the Problem] The process which forms the 1st transparent or translucent phase shift layer on (1) transparent substrate according to this invention in order to attain the above-mentioned purpose, (2) With this phase shift layer, it differs in etching nature on the phase shift layer of the above 1st. And the process and [drawing 1 (a) which form the 2nd translucent phase shift layer with fully thick thickness from this phase shift layer, The process which forms the etching mask which has opening on the field which should form a transparent field on the phase shift layer of] and the drawing 2 (a) drawing 3 (a)(3) above 2nd, (4) -- the process which **********s the 2nd phase shift layer alternatively by the etching method which has an anisotropy and has selectivity to the phase shift layer of the above 1st, and [(c) view --] -- (-- five --) -- ****** -- (-- four --) -- a process -- a result -- having exposed -- the above -- the -- one -- a phase shift -- a layer -- being isotropic -- etching -- a method -- **********ing -- a process -- [-- (-- d --) -- a view --] -- having -- a phase shift -- a mask -- manufacture -- a method -- ** -- providing -- having .

[Translation done.]

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EXAMPLE

[Example] Next, the example of this invention is explained with reference to a drawing.

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] The order cross section of a process for explaining the manufacture method of the 1st example of this invention.
[Drawing 2] The order cross section of a process for explaining the manufacture method of the 2nd example of this invention.
[Drawing 3] The order cross section of a process for explaining the manufacture method of the 3rd example of this invention.
[Drawing 4] The cross section of the conventional halftone method phase shift mask.
[Description of Notations]
1 Transparent Substrate
2 Semi-transparent Membrane
2a The 1st semi-transparent membrane
2b The 2nd semi-transparent membrane
3 Transparent Membrane
4 Photopolymer

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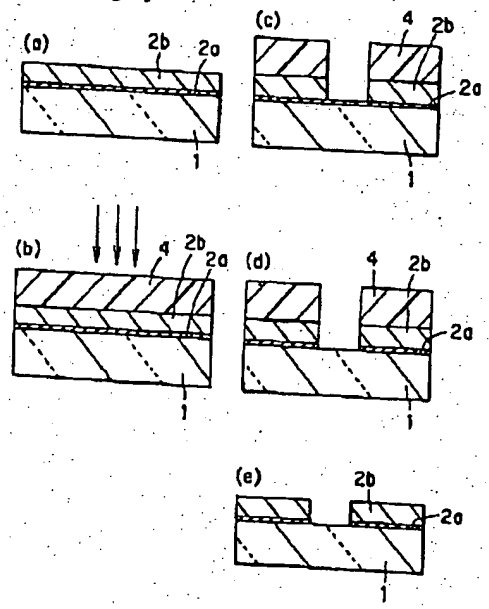
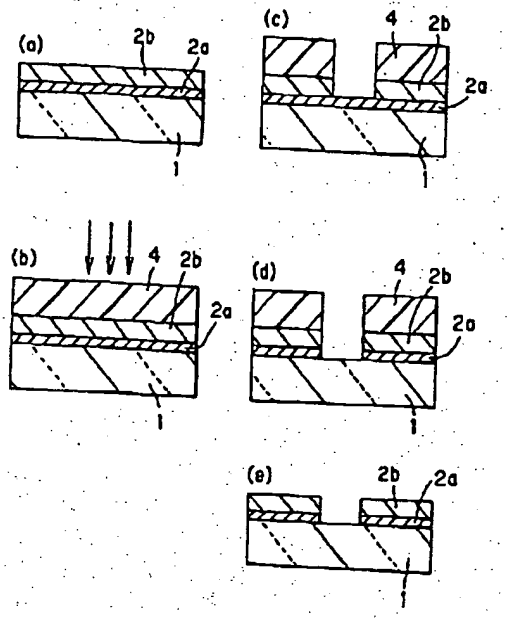
DRAWINGS

[Drawing 1]

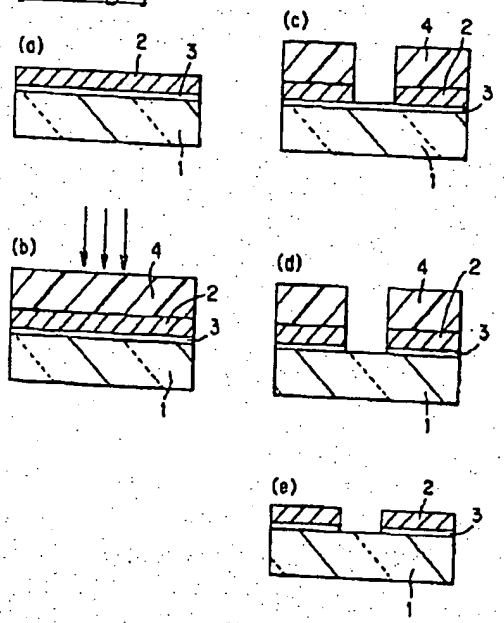


1 … 透明基板
2a … 第1の半透明膜
2b … 第2の半透明膜
4 … 感光性樹脂

[Drawing 2]

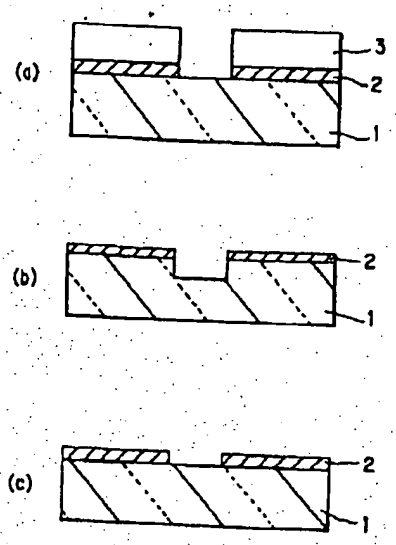


[Drawing 3]



2－半透明膜
3－透明膜

[Drawing 4]



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